

Appendix C:

March 22, 2004

Addendum to original report

This addendum to the original document includes the following four items:

- 1) Results of seven tritium samples previously unreported due to analysis complications,
- 2) Results of radiocarbon dating of two organic samples from borehole BL3,
- 3) Well installation information for a drive point piezometer that is intended to replace BL3-S, and
- 4) Explanation for not completing nitrogen isotope analyses.

Tritium

Seven of the original 42 samples collected for tritium had to be resealed for reanalysis because of complications caused by excess gas in the holding flask. Included below is Table C1 (an updated version of Table 6) showing the results of these seven samples (CR2-river, N3-8, N6-9, W1-4, N9-4, BL2-D, and BL3-D) in bold type. Sample N9-4 was erroneously reported as not NS (not sampled) in the original table (it should have been reported as resealed.) The measurement errors associated with three of the reported concentrations in Table C1 are large due to the same problems encountered during the initial analyses and some explanation is due. The laboratory preparation of these water samples includes removing all excess dissolved gas on a vacuum line aided by heating and sonic vibration prior to sealing the sample and allowing for ^3He ingrowth from the decay of tritium. Then the concentration of tritium in a sample is calculated based on measuring the concentration of its daughter product, ^3He after a known period of decay. In a perfect measurement, all ^3He measured would have come from tritium decay. However, incomplete degassing of the sample or a leaking sample flask could result in measuring ^3He that did not come from tritium decay during the holding time. In the calculation of tritium units (TU), the excess ^3He is estimated and subtracted from the total based on measuring ^4He and using the known atmospheric ratio of $^3\text{He}/^4\text{He}$. The fact that much of the groundwater at the site has very high dissolved gas pressures (and up to 1000 times as much dissolved helium as is common in groundwater samples) has likely complicated the degassing of some of these samples and it is impossible to precisely know what fraction of measured ^3He is from tritium decay and what fraction is from atmospheric leaking. As a result of these complications, analysis of the sample from W1-4 failed and the precision of three samples is high.

In examining these results combined with the reported errors we find no reason to amend the original interpretation of tritium concentrations in waters across the site. This is because the re-run data that have small margins of error are consistent with the original conclusions. Three of the re-run samples have margins of error that are as large as the reported value and therefore these data are not reliable and were not used to reach any conclusions. The river water sample from CR2 is in good agreement with the river water sample from CR1, after consideration of the respective concentrations and error terms reported. Groundwater at N3-8, BL2-D, and BL3-D are expected to be pre-bomb water that is essentially tritium-free. While water from N3-8 has very little tritium, samples from BL2-D and BL3-D were among the most contaminated samples and likely contain very little, if any tritium, but

these results are not reliable due to the large margin of error. Finally, waters from N6-9 and N9-4 are relatively shallow with low TDS and contain modest components of young (tritiated) water.

Sample ID	R/Ra	Tritium (TU)	³ H plus/minus	Terr ⁴ He (ccSTP/g)	Sample ID	R/Ra	Tritium (TU)	³ H plus/minus	Terr ⁴ He (ccSTP/g)
CR1-river	NS	12.02	0.60	NS	N9-4	1.180	4.65	1.22	5.8E-09
CR2-river	NS	9.99	2.49	NS	N9-6	NS	8.79	0.44	NS
N3-surface	NS	1.07	0.05	NS	N11-6	0.490	4.30	0.21	2.6E-08
CR1-3	0.105	1.21	0.24	4.5E-06	N11-10	0.103	NS	NS	9.0E-07
M11-7	0.969	4.73	0.24	0.0E+00	SMI-PZ1S	0.418	17.57	0.88	4.1E-08
M11-12	0.221	3.51	0.18	1.9E-07	SMI-PZ1M	0.190	14.54	0.73	1.8E-07
M11-14	0.127	0.96	0.05	1.0E-06	SMI-PZ1D	0.169	5.60	0.28	1.6E-07
N3-4	0.486	1.53	0.08	5.2E-08	ATP-1-S	0.071	< 0.1	0.04	6.8E-07
N3-8	0.926	0.06	0.02	4.1E-09	ATP-1-1S	0.065	0.22	0.01	2.3E-06
N4-6	0.932	8.95	0.45	3.0E-08	ATP-1-1D	0.062	0.52	0.03	2.3E-06
N4-12	1.785	10.46	0.52	0.0E+00	ATP-1-D	0.062	0.15	0.02	2.4E-06
N5-7	1.146	12.13	0.61	0.0E+00	SMI-PZ3-D2	0.114	8.69	0.43	7.8E-07
N5-10	1.071	9.16	0.46	0.0E+00	Atlas 432	1.088	< 0.1	0.00	0.0E+00
N5-14	1.102	9.45	0.45	0.0E+00	Atlas 433	0.142	0.60	0.03	6.2E-07
N6-6	0.397	1.38	0.07	8.0E-08	BL1-S	0.127	0.91	0.05	6.6E-07
N6-9	0.385	*5.21	4.12	9.4E-08	BL1-M	0.091	< 0.1	0.04	2.4E-06
N7-7	0.803	1.29	0.06	8.6E-09	BL1-D	0.079	< 0.1	0.23	2.9E-06
N7-10	0.141	< 0.1	0.06	1.3E-07	BL2-S	0.079	< 0.1	0.02	2.4E-06
N7-11	0.071	NS	NS	1.2E-06	BL2-M	0.074	< 0.1	0.15	2.6E-06
N8-10	0.981	6.09	0.30	5.6E-10	BL2-D	0.069	*5.75	5.69	2.3E-06
N8-14	0.965	5.02	0.25	5.2E-10	BL3-S	NS	NS	NS	NS
W1-4	0.398	NR	NR	3.8E-08	BL3-M	0.085	2.89	0.14	1.2E-06
W1-7	0.038	4.26	0.21	6.0E-08	BL3-D	0.065	*7.89	8.63	3.0E-06

Table C1 (amended from Table 6). Tritium and dissolved gas data from surface and ground water samples collected during July and August, 2003. Samples were analyzed by University of Utah Dissolved Gas Service Center during September and October, 2003. NS indicates “not sampled” and NR indicates “not reported” due to failed analysis.

*Value has a large margin of error and is not reliable.

Radiocarbon Dates

Two samples of organic material were submitted to Beta Analytic Inc. (BAI) in Miami, Florida for radiocarbon dating. These samples were collected from 24 and 30 feet below ground surface and are labeled accordingly in Table C2. A copy of the original BAI laboratory results is attached below.

Sample	Material	Measured Radiocarbon Age (years BP)	$^{13}\text{C}/^{12}\text{C}$ (permil)	Conventional Radiocarbon Age (years BP)
BL3-24	wood	20 +/-60	-24.8	30 +/-60
BL3-30	peat	910 +/-50	-25.0	910 +/-50

Table C2. Results of radiocarbon dating of two samples of organic material collected from core of the BL3 borehole drilled in August, 2003. Samples were analyzed by Beta Analytic Inc., Miami, FL.

The “Conventional Radiocarbon Age” listed in Table C2 is the result after applying $^{13}\text{C}/^{12}\text{C}$ corrections to the measured age and is the most appropriate radiocarbon age. Sample BL3-24 was a piece of wood found in fine-grained sand below the tamarisk root zone (see BL3 boring log in Appendix A) and has a conventional radiocarbon age of 30 +/- 60 years before present (by convention, present = 1950 A.D.). Sample BL3-30 was from a layer of peat found stratigraphically beneath a layer of sand and rounded gravel (~8 cm) as shown in Figure C1 below. Sample BL3-30 has a conventional radiocarbon age of 910 +/- 50 years before present.

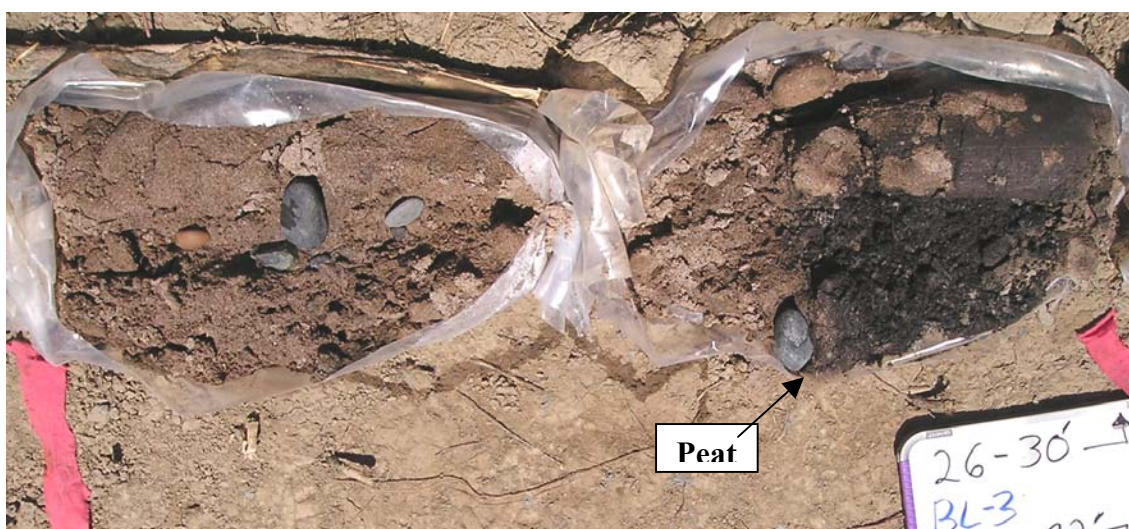


Figure C1. Photograph of borings from 26 to 30 feet below land surface from borehole BL3 showing peat layer and overlying sand and gravel.

The radiocarbon ages of these two samples indicate that there have been two flood events in the last 1000 years that have scoured down to 24 and 30 feet below present land surface, respectively, at a distance of more than 260 feet from the present river channel. At a minimum, it is important to emphasize that channel scour of this magnitude has occurred and needs to be incorporated into any model attempting to accurately predict river migration.

BL3-S2 Piezometer

No groundwater samples were collected from the original BL3-S since the filter pack interval of that well was contaminated by bentonite slurry resulting from heaving sands during well construction. Piezometer BL3-S2 has been installed to replace this well for future sampling. The piezometer was installed directly next to the original BL3 nest by University of Utah staff. Well installation information is included in Table C3 below. Immediately after installation the piezometer was fully developed, and now yields clear groundwater for future sampling.

Well / PZ ID	Type of Installation	ID (cm)	ID (in)	Easting (UTM)	Northing (UTM)	TOC Elevation (m)	Depth to Center of Screen Below MP (m)	Screen Length (m)	Screen Length (ft)
BL3-S2	Drive pt. PZ	1.27	0.50	623533.69	4271026.80	1208.54	9.25	0.31	1.0

Table C3. Well installation information for piezometers BL3-S2 including; type of installation, survey coordinates, top of casing elevation, depth to center point of screen below measuring point, and screen length. Horizontal survey coordinates are UTM relative to NAD 27 datum.

Nitrogen Isotope Analyses

As part of our field program samples were collected for the analysis of nitrogen isotopes on dissolved nitrogen species. Because of the extreme range in salinity and dissolved nitrogen concentrations, we were not able to find a suitable technique for analyzing all samples. Samples with low salinity could have been measured using an ion exchange technique, but high concentrations of salt (greater than about 5000 mg/L) interfere with this method. A distillation technique for high salinity, high nitrogen samples was successfully developed, but this method proved to be imprecise for samples containing less than 10 mg/L NH_3 as N. Because our objective was to compare nitrogen isotope values across the entire site,

employing two separate methods was not deemed to be suitable. An agreement with the State of Utah was reached whereby we would not provide (or charge for) any nitrogen isotope analyses.

Analytical Results from Beta Analytic

Dr. Phil Gardner

Report Date: 2/17/2004

University of Utah

Material Received: 1/20/2004

Sample Data	Measured Radiocarbon Age	¹³ C/ ¹² C Ratio	Conventional Radiocarbon Age(*)
Beta - 188270 SAMPLE : BL3-24 ANALYSIS : Radiometric-Standard delivery MATERIAL/PRETREATMENT : (wood): acid/alkali/acid 2 SIGMA CALIBRATION : (result is outside of the calibration range)	20 +/- 60 BP = <i>99.7 ± 0.7</i> <i>PMC</i>	-24.8 o/oo	30 +/- 60 BP
Beta - 188271 SAMPLE : BL3-30 ANALYSIS : Radiometric-Standard delivery MATERIAL/PRETREATMENT : (peat): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1015 to 1235 (Cal BP 935 to 715)	910 +/- 50 BP	-25.0 o/oo	910 +/- 50 BP

over

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25;lab. mult=1)

Laboratory number: **Beta-188271**

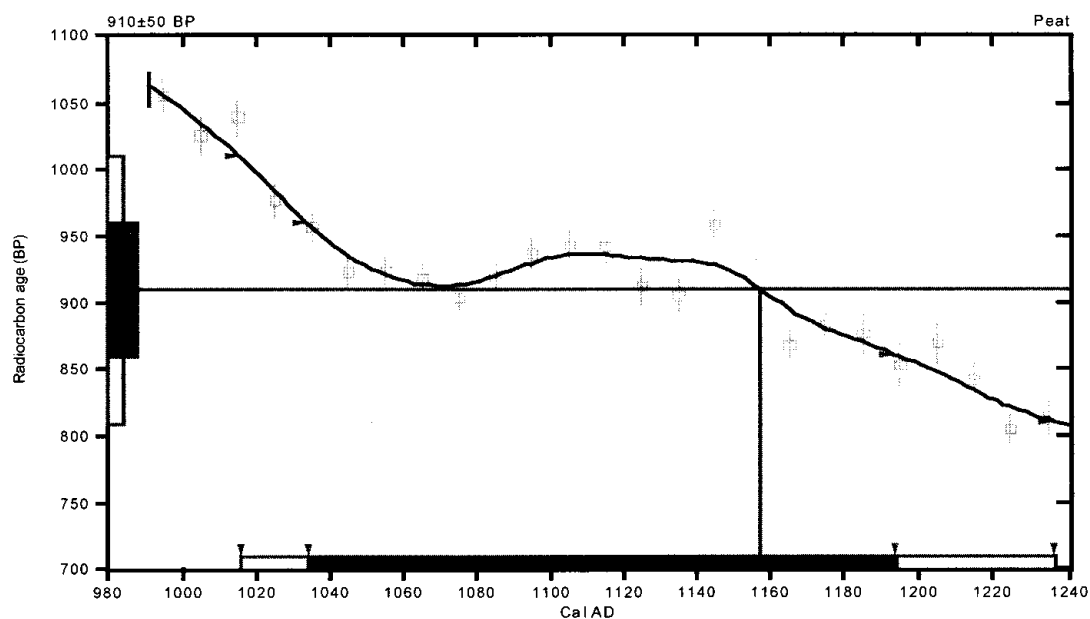
Conventional radiocarbon age: **910±50 BP**

2 Sigma calibrated result: **Cal AD 1015 to 1235 (Cal BP 935 to 715)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: **Cal AD 1155 (Cal BP 795)**

1 Sigma calibrated result: **Cal AD 1035 to 1195 (Cal BP 915 to 755)**
(68% probability)



References:

Database used

Intcal98

Calibration Database

Editorial Comment

Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxi-xiii

INTCAL98 Radiocarbon Age Calibration

Stuiver, M., et al., 1998, Radiocarbon 40(3), p1041-1083

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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